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(54) HERMETICALLY PACKED FOODS

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HERMETICALLY PACKED FOODS

This invention is related to high quality hermetically packed foods, sterilized at a high temperature for a short period, and is particularly related to hermetically packed foods which are sterilized at 115-150°C for a short period and exhibit little reduction in food values such as flavor, color, texture, etc.

Hermetically packed foods distributed at room temperature include canned foods, bottled foods, retort pouch foods, etc. Various thermal sterilization treatments are adopted for these foods, depending on the pH, water activity and thermal conductivity of the foods; size of the containers, etc. Especially for the foods which have a pH higher than 5.5 (called nonacidic foods, below) and a water activity of more than 0.94, it is legally mandatory in certain jurisdictions to carry out the sterilization by heating the center portion of the packages (the most slowly heated part) at 120°C for 4 minutes, or by an equally effective or more sterilization effective method.

The condition of heating at 120°C for 4 minutes is the condition for the complete elimination of the spores of Clostridium botulinum type A strain which produces the deadliest toxin and causes food sanitation problems, and it corresponds to a value of 3.1 if converted to the sterilization number F_0. Therefore, the above-described method is equally or more efficient if the condition of heating at 120°C for 4 minutes based on the Z value of Cl. botulinum is converted to heating at 115°C for 13 minutes, 110°C for 40 minutes, or 105°C for 130 minutes.

The condition described above is the temperature condition at the center portion of the packages. Thus, it is necessary to consider the time required for the heat to reach the center portion. Therefore, the practical heating time depends on the size of packages, etc., and it is generally 120°C for 25-30 minutes for low-acidic retort pouch foods, 110-120°C for 40-90 minutes for canned foods to obtain a storability at room temperature as a hermetically packed food. However, reduction in the quality of the foods cannot be avoided by heat treatment for a long period as described. On the other hand, in foods with a pH less than 5.5 and with a water activity less than 0.94, the heat-resistance of the microorganisms causing the deterioration of foods is reduced. Thus, it is possible to carry out the thermal sterilization under more moderate conditions than those described above. The sterilization number F_0 is explained later in the specification.

Previously, in the case where foods with a pH in the weakly acidic range of 4.5-5.5 or in the acidic range of below 4.5 are sterilized, the heating time was kept the same but the temperature was reduced in order to accomplish complete sterilization, although the heat-resistance of the microorganisms causing the deterioration of foods has been known to be reduced. For example, as in the sterilization of canned fruits, the temperature has been reduced to 100°C or lower. In addition, as in canned bamboo shoots, there has been an attempt to accomplish complete sterilization by denaturing the bamboo shoot itself and carrying out the thermal sterilization when the pH is reduced to a proper value. These foods are packed in a large can and the thermal conductivity is low. Thus, treatment at high temperature is impossible, and the heating is carried out at a temperature around 100°C for a long period. An attempt is made to reduce the time by lowering the pH as much as possible, but it still requires about 100 minutes. There has been no attempt to carry out the treatment at a high

temperature for a short period. Similarly, for beans the pH is adjusted, but carrying out the sterilization at a high temperature for a short period has not been considered. There are some cases for "udon" (Japanese noodles), etc., where the pH was adjusted, but this was carried out to supplement the pasturization with which the sterilization may be insufficient, and there was no intention of adopting the sterilization at a high temperature for a short period to obtain complete sterilization.

These packed foods are generally processed by pasturization (the processing time is generally 40-100 minutes). Thus, they deteriorate easily when they are distributed at room temperature. Therefore, it is expected that the lowered pH compared to that of low acidic foods will have a growth-inhibiting effect on the micro-organisms, but still the foods are distributed, requiring the storage in a refrigerated case as a prerequisite. The main reason for this is that the operation for the treatment is carried out at a temperature below 100°C at atmospheric pressure, requiring no special installation for the treatment under high pressure.

The thermal sterilization treatment described above is accomplished by an increase in the heating time. Thus, deterioration of the nutrient components in the foods and damage to the flavor, color, vitamin, texture, etc., cannot be avoided.

This invention proposes to solve the above-described shortcomings of the previous hermetically packed foods which were thermally sterilized, and the object of this invention if to provide high quality hermetically packed foods which may be distributed at room temperature and have excellent nutrition, flavor, color, texture, etc., by thermally sterilizing low pH foods at a high temperatur for a short period, reducing the heating time of the foods.

According to this inventi n, hermetically packed packages c ntaining foods, which foods are packed, sealed in

heat-resistant packing materials, sterilized at 115-150°C for a short period, and have a pH in the range of 4.0-5.5, or water activity less than 0.94, and hermetically packed packages containing the foods described above with anti-souring agents added, may be provided.

This invention is explained further in detail as follows.

The heat-resistant packing material in which the foods of this invention are packed and sealed may be those which can tolerate the thermal treatment at a temperature in the range of 115-150°C for a short period, and definite examples of such packages are retortable pouches, cans, bottles, etc. Among these, the retortable pouches are optimum, being relatively thin thickness after the foods are packed. Thus, the temperature of the center portion reaches the required temperature in a short time period. In the case of cans and bottles, it is preferable that either the height or the diameter be less than about 100mm from the point of view of thermal conductivity. The sealing operation is generally carried out by heat-sealing in the case of the retortable pouches; the double seam sealing method in the case of cans; and mechanical sealing with metal caps lined with rubber, vinyl chloride, polyethylene, etc., in the case of bottles.

It is important that the hermetically packed foods of this invention have a pH in the range of 4.0-5.5 or that the water activity be less than 0.93. If the pH is above 5.5 or the water activity is above 0.94, heating for a long period is required since thermal sterilization according to the heat resistance of microorganisms or their spores in order to eliminate the microorganisms, including Cl. botulinum, completely may cause the deterioration of foods, as described above, and as a result the quality of the foods is reduced. Furthermore, the necessary thermal sterilization conditions are generally mitigated by lowering the pH of foods.

With the above and other objects in view that will hereinafter appear, the nature of the invention will be more clearly understood by reference to the following detailed description, the appended claims, and the several views illustrated in the accompanying drawings.

IN THE DRAWINGS:

Figure 1 is a graph showing the relationship of pH with heating temperature-time required for the complete elimination of spores of Bacillus coagulans.

Figure 2 is a graph showing the relationship of pH with the D values which show the spore elimination effect by heating.

Figure 3 is a series of graphs showing the relationship of the browning-heating time of glycine-glucuse solution for different pH values and heating temperatures.

Figure 1 shows the time required for the complete elimination of the spores of a typical food deteriorating bacterium, Bacillus coagulans in 1/15 M citric acid-phosphoric acid buffer with a concentration of 10^4/cc and with the pH adjusted to 4.5, 5.5, or 7.0 and heated at a temperature in the range of 100-130°C. If the food with a pH of 7.0 is contaminated with this bacterium, the graph of Figure 1 indicates that the food requires a thermal treatment at 120°C for 1.8 minutes for complete sterilization. If the pH of the food is adjusted to 4.5, complete sterilization is possible by heating at 120°C for 0.4 minutes (25 seconds). The time required is 1.8 minutes at 114°C, and 0.1 minutes (6 seconds) at 125°C for complete sterilization.

As described, the lower the pH of the foods the shorter the sterilization time at the same temperature, and the effect of lowering the pH is extremely apparent at a pH below 5.5. It is insignificant above 5.5, as shown in Figure 2.

The graph of Figure 2 shows the relationship between the pH on the horizontal axis and the D value on

the vertical axis, which indicates the elimination effect of bacterial spores (Bacillus coagulans, concentration 10^4 spores/cc) by heating. The D value is the time required to reduce the microorganisms or spores to a constant concentration of 1/10 under constant conditions, and the smaller the D value the larger is the elimination effect. The graph of Figure 2 indicates that the effect described above is suddenly reduced above pH 5.5.

Another reason that the object of this invention is to package foods with pH less than 5.5 is that the effect of heating on the quality of foods is suddenly reduced when the pH is lower than 5.5.

The graphs of Figure 3 show the relation of the browning behavior (shown as transparency) of a 1/20 M glycine-glucose solution as a function of pH, heating temperature and time. The browning of foods by heating is said to be due to the sugar-amino acid reaction, but at the same temperature and time the extent of browning is significantly lowered when the pH is 5.5 as compared to when it is 6.2 or 7.0. This effect is not only observed in the color but also in the nutrient components such as vitamins, etc., flavor, taste, etc.

However, except for foods the pH of which is characteristically low and have a sour taste, low or non-acidic foods always have a sour taste when the pH is adjusted below 4.0 by adding pH-adjusting agents as described later in this specification and as a result the original taste of the foods is lost. On the other hand, when the pH of the low or non-acidic foods is adjusted to above 4.0 (but below pH 5.5), there are some which do not have any sour taste, depending on the variety of foods, or have a very weak sour taste which is easily removed by adding anti-souring agents, to maintain the original taste of the foods. Thus, the lower limit of the pH is set to be 4.0.

The foods with the original pH in the range of 4.0-5.5 are foods cooked with soy sauce such as akagai

(red clam), etc., vegetables boiled in water such as butterbur, mushrooms, asparagus, spinach, etc., black beans (cooked with soy sauce or sugar), fukujinzuke (Japanese pickle), etc. For the foods with pH above 5.5 (nonacidic foods), this invention is applied after the pH was adjusted to the range of 4.0-5.5 by adding pH-adjusting agents in the process of packing the foods into packing materials.

Previously it was considered that since there were many foods the pH of which was difficult to adjust because the buffering capacity (capacity to maintain the pH to the original value) of each food was very high, the reduction in the pH gave necessarily a sour taste, damaging the original taste of the foods. However, in accordance with this invention it has been found that the pH of the low acidic foods could be adjusted to below 5.5 by considering the strength of the buffering capacity characteristic for each food, extent of processing, combination of food materials, flavoring techniques, selection of pH-adjusting agents, etc., and it was possible to obtain normal taste and flavor by selecting pH-adjusting agents which did not give an astringent taste to foods and adding antisouring agents if necessary.

The substances to reduce the pH of foods are preferably organic acids which have to be harmless. Organic acids of this kind are acetic acid, succinic acid, lactic acid, malic acid, tartaric acid, citric acid, fumaric acid, ascorbic acid, their acidic salts, vinegar, etc. Other pH-adjusting agents such as fluconodeltalactone, etc., may certainly be used.

The antisouring agents are preferably sweeteners, natural or artificial, and they are not especially limited. For example, they are sorbitol, glucose, fructose, xylose, mannose, mannitol, cane sugar, lactose, raffinose, galactose, rhamnose, malt sugar, saccharine, sodium saccharine, sodium glycol-lysine, xylitol, sorbose, reducing sugars, honey, starch syrup, etc.

The amount of pH-adjusting agents to be added to reduce the pH to below 5.5 depends on the buffering capacity of the foods, and several varieties of pH-adjusting agents may be used at the same time. Thus, it is difficult to limit it to a numerical value. In case antisouring agents are added, the amount is basically the same as that of the pH-adjusting agents used, but the intensity of the sour taste is different, that is, some foods do necessarily give sour taste depending on the heaviness of the taste or the seasonings added. Thus, the addition and amount are determined depending on the variety of the foods.

The proper method for the adjustment of pH has to be selected depending on the state of the foods, that is, whether they are pure liquid foods, solid-liquid mixed foods, or pure solid foods, so that the distribution of pH would be homogeneous. In the case of pure liquid foods, this is relatively easy by adding the amount necessary, depending on the buffering capacity of the foods, in order to adjust the pH to the required value, and the mixture is homogenized using a blender or homogenizer. For the foods with small solids mixed in the liquid, the pH adjustment has to be carried out separately on the liquid and solid substances. The pH of solids may be adjusted by dipping the solids into a solution with the required pH (the liquid with its pH already adjusted may be used), by repeating vacuum degassing after the dipping, or by dipping and boiling, etc. Especially the vacuum degassing operation may be carried out at room temperature. Thus, no reduction in the quality of the foods is observed, and the pH is adjusted uniformly all the way to the inside in a short time. The liquid and solid with their pH's adjusted separately are mixed, packed, sealed in packing materials, and thermally sterilized. The independent adjustment of the pH of the solid and liquid is important and it is apparent in the following example of canned tuna with a dressing. It is produced by packing and sealing steamed tuna cut into a

certain size and the dressing containing vegetables. The packed and sealed tuna with dressing is sterilized at 117°C for 90 minutes. The pH of the product is found to be 4.9, using the usual method of measurement. This is, the measurement is carried out mixing the entire contents and sampling a certain amount. In spite of this pH value, the same sterilization conditions as those for nonacidic foods have to be used since the pH of the fish meat is around the neutral range and only the dressing has a pH in the range of 3.0-3.2 during the sterilization treatment. Thus, it is difficult to carry out the complete sterilization at a low temperature. Namely, for foods of this kind the thermal sterilization has to be carried out under the same conditions as those for the low acidic foods, due to the heterogeneous characteristic, in spite of the low average pH. Therefore, in order to apply this invention, independent pH adjustment for solid and liquid is necessary.

In the case of pure solid foods, the method described above may be utilized. In addition, in the case of pasty foods which are prepared by mixing the raw materials using a chopper or kneading machine and then forming, the pH adjusting agents and antisouring agents may be mixed uniformly in the mixing process.

In the case of foods with a characteristic pH below 5.5, they can certainly be sterilized thermally as they are.

The water activity is the A_w value obtained from the equation

$$A_w = P/P_0,$$

where P_0 is the equilibrium vapor pressure of pure water at a constant temperature, and P is the equilibrium vapor pressure of water in the system (food) at the same temperature. If there is only pure water (100% water content), $A_w = 1$, and $A_w = 0$ in the case of anhydrides. The water activity affects the growth of microorganisms similarly to the pH, and the lower the water activity, the more limited

is the variety of microorganisms which can grow. Examples of foods with a water activity below 0.94 are chestnuts cooked with sugar, noritsukudani (seaweed cooked with sugar and soy sauce), fukujinzuke (Japanese pickle), bonito meat squares cooked with sugar and soy sauce, taidenpu (red snapper cooked with salt and sugar and pulverized), oyster sauce, cooked agalloch, akamiso (red soybean paste), cooked lima beans, etc.

It is important in this invention to carry out the thermal sterilization treatment of the foods with a pH in the range of 4.0-5.5 or with a water activity below 0.94, as described above, at a temperature in the range of 115-150°C for a short period. If the temperature is below 115°C, the heating time is long, causing the deterioration of the quality of the foods, and on the other hand if it is above 150°C the heating time is shortened but deterioration due to overheating, such as color change, etc., may be observed. The effect of the temperature on the quality of consomme soup is shown in Table 1, as a result of one experiment.

Table 1

pH unadjusted (6.0)		pH adjusted (4.9)	
sterilization condition (F_0 = 5)	1) transmittance (%)	sterilization condition (F_0 = 0.17)	1) transmittance (%)
		212°F minutes	
		100°C - 49	43.0
		105 - 29	43.0
		110 - 16	43.5
		115 - 9.6	44.2
		120 - 5.6	45.0
		125 - 3.2	45.5
105°C - 41 min.	43.2	130 - 1.9	46.2
		135 - 1.2	46.8
		140 - 0.9	47.1
		145 - 0.7	47.2
		150 - 0.6	45.1
		155 - 0.5	43.5
		160 - 0.4	41.5

220°F
320°F

Note: 1) The transmittance was measured using a Hitachi Automatic Spectrophotometer, Model EPS-3T, at a wavelength of 430 nm. The higher the transmittance the lower the degree of browning. The transmittance of the unheated product was 47.2%.

In the experiment, 180 g of consomme soup was packed and sealed in a retort pouch. The pH was 6.0. Generally, it is desirable to sterilize the soup with a standard sterilization value of $F_0 = 5$, and, to do so, treatment at 105°C for 41 minutes is necessary. If the pH of the soup is reduced to 4.9 using citric acid, the sterilization value F_0 of 0.17, in order to obtain the same level of sterilization. Previously, the thermal treatment of the foods such as soup described above, etc., with their pH adjusted, was carried out at 100°C for 49 minutes. Table 1 shows the time required to obtain the same sterilization level at a temperature in the range of 105-160°C, and transparency after treatment. It is apparent from Table 1 that the heating time is extremely shortened by thermal treatment at an extremely high temperature in the case of actual foods. The transparency in Table 1 indicates the extent of browning after the treatment. As it is apparent from Table 1, adopting temperatures to below 110°C gives no significant reduction in the heating time, and at the same time there is not much difference in the quality from that in the previous method, and thus the prior method should be avoided. A temperature above 150°C is not preferred, since the quality after the treatment is lower than that in the previous method, even in liquid foods which have a good thermal conductivity.

The sterilization value F_0 is the time in minutes required for the complete elimination of microorganisms or their spores when they are exposed to a temperature of 121°C. In Figure 1, the F_0 value of the spore of Bacillus coagulans in a buffer at pH 7.0 is 1.4. The value becomes certainly smaller with decreasing pH. Namely, the F_0 value

shows the heat resistance of microorganisms or their spores subjected to sterilization, and it is a measure of the complete sterilization of foods in case the foods are contaminated by them. In general, packed foods have a certain thickness, and the thermal conductivity is different at different parts of the foods in case they are heated from the outside. Namely, in the above example only the part near the surface is sterilized by heating at 121°C for 1.4 minutes and the heating is completed with the center portion unsterilized. Thus, in order to sterilize uniformly, the heating is carried out so that the portion which has the slowest thermal conductivity has $F_0 = 1.4$. Therefore, the more difficult is the conduction of heat in the foods, the longer is the heating time required. Furthermore, the slowest heating point is not treated at the temperature used from the beginning of the heating, the temperature is raised gradually with time to the temperature used for the treatment, and there is a certain sterilization effect as the temperature is raised. Thus, the heating has to be carried out until the integrated value of L shown by

$$L = \log^{-1} \frac{T-250}{Z}$$

(L = sterilization efficiency, T = temperature raised in a small range of the heating time °F, Z = heat resistance of microorganisms or their spores). In the spore-elimination time-temperature plots in Figure 1, the temperature at which the straight lines cross one logarithmic period becomes the F_0 value.

The heating time in this invention is defined as the time the foods sealed in packing materials are maintained in the heating medium at a required temperature. The heating apparatus used in this invention is the so-called continuous retort or batch high-temperature and pressure sterilizer. The heating medium of the apparatus may be saturated steam, steam-air mixture, hot water, microwave, infrared ray, etc. In some cases, depending on the variety of the heat-resistant containers, the thermal treatment may be carried

out with a slight air pressure in addition to the saturated steam pressure at the temperature used. The heating and cooling are desirably carried out as quickly as possible. Therefore, as soon as the required heating time is completed, the packages are generally cooled by immersion into cold water. By doing so, the deterioration of the quality of the content foods due to gradual cooling may be prevented.

The heating time depends on the F_0 value of the foods, on the thermal conductivity coefficient, heating temperature, etc., but in order to accomplish the object of this invention, that is, the prevention of the deterioration of the quality of foods by reducing the heating history, it is desirable for it to be as short as possible for complete sterilization, that is, within 20 minutes, preferably 15 minutes.

Furthermore, simultaneous utilization of preheating at a temperature in the range of about 80-100°C for a short period (about 4-10 minutes), shortens the heating time at a temperature in the range of 115-150°C significantly and effectively reduces the deterioration in the quality, as shown in Practical Examples 3 and 4.

As described, the thermal sterilization treatment is possible in a short time, according to this invention. Thus, a high productivity may be obtained and, at the same time, hermetically packed foods distributed at room temperature which have excellent qualities such as taste, flavor, color, transparency, texture (bite feel, etc.) may be prepared.

The effect of this invention is clearly shown further using practical examples as follows:

Practical Example 1

Beef consomme, 5 liters, was prepared by cooking 6 liters of bouillon, 600 g of coarse ground beef, 150 g of carrots, 240 g of onions, 60 g of celery, 60 g of scallions, 6 leaves f parsley, 6 eggs, and 9 g of salt (Sample 1). The spores of the putrefactive bacterium Cl. sporogenes,

NCA-PA-3679 was inoculated into the soup so that the concentration was 10^5 spores/1 ml of consomme.

The pH of the consomme was 6.0, and the one to be thermally treated under conditions to accomplish a sterilization value of $F_0 = 5$, that is, 105°C at 41 minutes, was called Sample 2. Sample 3 was prepared by adding 1 ml of 1/10 M citric acid solution per 100 cc of the consomme to adjust the pH to 5.0. It was found that the sterilization value $F_0 = 0.17$ would provide to the pH-adjusted consomme the same complete sterilization effect as that of the unadjusted consomme described above. The pH-adjusted consomme samples, thermally sterilized under conditions of 100°C for 49 minutes, 120°C for 5.6 minutes, or 135°C for 1.2 minutes are called Sample 4, Sample 5, or Sample 6, respectively.

The samples of consomme soup described above were packed and sealed in retort pouches (made by Toyo Seikan, registered brand name: hi-RP-F, polyester aluminum foil polypropylene, 130 x 170 mm thickness after packing: 10 mm the amount of content packed: 120g), and sterilized under the respective heating conditions using high temperature and short period retort sterilizer (made by Toyo Seikan, Model H60-C50-120/150-SWRA) to prepare the samples for the storage and putrefaction test. Samples 1 and 3 were not thermally treated. For the quality evaluation test, the same samples described above but without any inoculation of the spores were thermally treated under the same conditions. No thermal treatment was carried out for Samples 1 and 3.

The evaluation of the quality was carried out by a panel of fifteen persons with a 10-stage system for each sample, choosing Sample 2 as a standard sample, and giving 5 points to the best sample compared to it, and -5 points to the worst. The results are shown in Table 2 below. As described, beef consomme of excellent quality was prepared by adjusting the pH to 5.0.

The samples which were inoculated with spores were maintained at 37°C for 2 months in an isothermal room but none of them putrefied, except Samples 1 and 3.

Table 2

	Sample No.	Averaged Evaluation Point	Observation
Unheated Product	1	4.2	There were smell of beef, and good smell of celery and onion
Comparative Product	2	0	The smell of beef was lacking and the smell of vegetables was gone
Unheated Product	3	4.0	There was no sour taste due to the pH adjustment, the smell of beef and vegetables was present
Comparative Product	4	2.3	The smell of beef was reduced, and strong odor of vegetables was present. It seemed as if it was stewed
This Invention	5	3.2	The smell of beef remained and the odor of vegetables was weak
This Invention	6	3.8	The smell of beef was present inducing appetite

Practical Example 2

"Sekihan" was prepared by allowing to mix overnight 60 g of cowbean and 1 kg of rice dipped in a solution (pH 3.0) containing 0.16% of fumaric acid and 0.15% of cane sugar for the pH adjustment, immersing the mixture into the liquid in which the bean had been cooked for coloring, and finally steaming. The pH of the sekihan prepared was 5.2. The sekihan prepared, 180 g each, was packed, sealed in a retort pouch (made by Toyo Seikan, registered brand name: hi-RP-T, nylon-polypropylene, 130 x 170 mm thickness after packing: 15 mm), and sterilized thermally with the same retort sterilizers as those described in Practical Example 1.

The sweet rice used was contaminated with 10^4 spores/g of Bacillus coagulans spores and in order to eliminate it completely, the sterilization value $F_0 = 1.5$ had to be satisfied. Thus, for sekihan without its pH adjusted (pH 6.2), the thermal sterilization was carried out at 110°C for 25 minutes. In order to obtain the same sterilization effect in the sekihan with the pH adjusted to 5.2, heating at 100°C for 55 minutes was required. However, the complete sterilization could be carried out at 120 or 135°C in a short time of 15 or 6 minutes, respectively. The pouches, 50 each, thermally treated under the conditions described above, were stored at 37°C for 2 months in an isothermal room, but none putrefied.

Table 3

	Thermal Sterilization Conditions	pH Adjustment	1) a/b Value	2) Putrefaction
Comparative	no retort sterilization	not adjusted (pH 6.2)	0.70	present
Comparative	120°C for 25 minutes	not adjusted (pH 6.2)	0.96	none
Comparative	100°C for 55 minutes	adjusted (pH 5.2)	0.87	none
This Invention	120°C for 15 minutes	adjusted (pH 5.2)	0.82	none
This Invention	135°C for 6 minutes	adjusted (pH 5.2)	0.75	none

Note: 1) The measurement was carried out using a Nippon Denshoku Color Machine (CM-20) and a white standard board (L = 92.12, a = -0.17, b = 4.32). The values shown are the average values of n = 10.

2) Stored at 37°C for 2 months in an isothermal room.

Table 3 shows the color difference, a/b value, on the surface of packed sekihan (water activity of 0.98) under each of the conditions described above. The higher the a/b value, the stronger the dark red color. As it is apparent from the results shown in Table 3, the surface color of the

packed sekihan of this invention was darkened less than those of the sekihan without the pH adjustment, or treated at 100°C for a long period. Furthermore, there was no sour taste present, and the texture felt upon biting was good.

Practical Example 3

Carrots (water activity of 0.99) and onions (water activity of 0.99) were sliced in 1 cm thickness, were immersed into a 0.14% malic acid solution containing 1% of sodium chloride in a vacuum tank as they were in the raw condition, were degassed under vacuum from atmospheric pressure to 76 cm Hg, and the first operation of dipping and degassing was repeated until the pH inside the cell became 4.9. For the carrots, this required 6 minutes for 12 repetitions, and for the onions 4 minutes for 8 repetitions, to obtain the pH of 4.9. After the vacuum operation was completed, the vegetables were taken out from the immersion solution, washed lightly with water, and the pH was measured.

The carrots with their pH adjusted as described above, 55 g, and 55 g of 1/10 M aqueous solution of sodium citrate (pH 4.96) containing 0.2% of malt sugar (antisouring agent) were packed and sealed into a No. 2 baby food can (52.3 mm i.d., 45.5 mm height). For comparison, the carrots without their pH adjusted were packed and sealed with water similarly. In any case, the spore of Bacillus subtilis was added in an amount of 10^5 spore/cc (F_0 = 5.5 at pH 6.0). At pH 4.96, the heat resistance of the spore was reduced, and the F_0 was 3. The cans described above were thermally sterilized under the various conditions described in Table 4, using the same retort sterilizer as that in Practical Example 1. The preheating was carried out at 90°C for 5 minutes, and in case this preliminary heating was carried out, the high temperature heating time was shortened. The cans prepared under various heating conditions as described above, 50 each, were stored at 37°C for 2 months, but no putrefaction was observed.

Table 4

	Heating Conditions	pH Adjustment	Curdmeter value 1)	Color
Comparative	100°C for 38 minutes	adjusted (pH 4.9)	62.1	slightly faded
This invention	120°C for 12 minutes	adjusted (pH 4.9)	65.8	good
This invention	135°C for 5 minutes	adjusted (pH 4.9)	73.2	good
This invention	120°C for 9 minutes (preliminary heating)	adjusted (pH 4.9)	68.4	excellent
This invention	135°C for 3 minutes (preliminary heating)	adjusted (pH 4.9)	76.2	excellent
Comparative	120° for 18 minutes	not adjusted (pH 6.6)	45.1	faded

Note: 1) The measurement was carried out using an Iio type curdmeter (plunger 1.5 mm φ). The values shown are average values with n = 10.

Table 4 shows the texture (hardness) and color of the carrots treated under various conditions. The texture was evaluated with the numbers observed using a curdmeter. The higher the values, the harder is the curd. From the results shown in Table 4, it is apparent that the softening of the carrots by the thermal sterilization is prevented, and the color is maintained well, according to this invention.

Practical Example 4

Mushrooms, sliced in 1 cm thickness, were boiled at 100°C for 10 minutes in a solution prepared by mixing 1/10 M citric acid solution and water in a weight ratio of 8 : 12, to obtain a branching product (water activity of 1.00) with a pH of 4.9, which was packed, sealed and thermally sterilized under the same conditions as those in Practical Examine 3. The mushrooms without the pH adjusted were thermally sterilized at 120°C for 18 minutes as a control. For these products, the quality evaluation tests

were carried out with respect mainly to texture. The grading method was the same as the one used in Practical Example 1. The results are shown in Table 5 below. They indicate that the products of this invention give better texture than those of the comparative product. The cans (50 cans each) were stored at 37°C for 1 months without any putrefaction.

Table 5

	Heating Conditions	pH Adjustment	Average evaluation Points
Comparative	100°C for 38 minutes	adjusted (pH 4.9)	2.6
This invention	120°C for 12 minutes	adjusted (pH 4.9)	3.2
This invention	135°C for 5 minutes	adjusted (pH 4.9)	3.8
This invention	120°C for 9 minutes (preliminary heating)	adjusted (pH 4.9)	3.5
This invention	135°C for 3 minutes (preliminary heating)	adjusted (pH 4.9)	4.3
Comparative	120°C for 18 minutes	not adjusted (pH 6.6)	0

Practical Example 5

Mixed ground beef and pork, 200 g, 50 g of onion, with 4 cc of 1/10 M citric acid solution, added in advance, were mixed with 20 g of fresh bread crumbs to prepare raw hamburger steaks with 14 mm thickness, which were fried on a frying pan until both sides were browned. The pH of the hamburger steaks prepared was 4.8. A sauce (pH 4.8) prepared from 200 g of soup beef, 100 g of onions, 30 g of carrots, 4 tablespoons of flour, 2 cups of tomato juice, 5 cups of soup and 2 tablespoons of ketchup, was added to the fried hamburger steaks (pH 4.8), and this roasting condition was maintained for 10 minutes. The hamburger steaks with the sauce prepared as described showed pH of 4.80 and a water activity of 0.96. One of the hamburger

steaks prepared and about 80 g and 30 g of the sauce were packed and sealed in the same retort pouch as the one used in Practical Example 1, and the thermal sterilization treatment was carried out using the same sterilizer as the one used in Practical Example 1.

The hamburger steaks with pH adjusted (pH 6.1) had to be sterilized at 120°C for 20 minutes (sterilization treatment corresponding to 120°C for 20 minutes, that is F_0 = 3.1), but the one with a pH of 4.8, F_0 is 0.015, that is, the complete sterilization could be carried out at 100°C for 42 minutes, 120°C for 10 minutes, or 135°C for 5 minutes.

Using the hamburger steak thermally treated at 100°C for 42 minutes as a standard, a test for the evaluation of the overall quality, including taste, texture, etc., was scored with the same system as that used in Practical Example 1. The results are shown in Table 6 below. The products of this invention, whcih were thermally sterilized at a high temperature for a short period were excellent.

Table 6

	Heating Conditions	pH Adjustment	Average evaluation Points
Comparative	100°C for 42 minutes	adjusted (pH 4.8)	0
This Invention	120°C for 10 minutes	adjusted (pH 4.8)	1.8
This invention	135°C for 5 minutes	adjusted (pH 4.8)	2.7

Spores of Clostridium sporogenes, NCA-PA3679 were inoculated into the hamburger steaks described above in an amount of 10^3 spores/g (F_0 = 3.1). Fifty packages each were sterilized under each of the conditions described above, and were stored at 37°C for 2 months, but no putrefaction was observed.

Practical Example 6

Minced A grade frozen cod, 1 kg, 300 g of potat starch, and 30 g of table salt were kneaded. Gluconodeltalactone (Kishida Kagaku), 28 g, 6 g of citric acid, and 50 g

of cane sugar (antisouring agent) were added to the mixture, and were mixed for 10 minutes using an Ishikawa-type 101 stirring kneader. The mixture prepared was steamed in a steamer and gelled. The pH of the gel prepared was changed from 6.95 to 5.30 by the procedures described above, but there was no sour taste present. The water activity of the gel was 0.965.

The gel was prepared to 14 mm thickness, packed, and vacuum-sealed in retort pouches (hi-RP-T). The gel without pH adjustment required a sterilization treatment of 120°C for 20 minutes (corresponding to sterilization of 4 minutes at 120°C, that is, F_0 = 3.1), but when the pH was 5.30, the F_0 was 1.1, and complete sterilization could be carried out at 120°C for 11 minutes, or 135°C for 5.6 minutes. Table 7 below shows the degree of whiteness (L value) of the pasty products produced and treated under various conditions. From the results shown in Table 7, it is apparent that the products of this invention treated at a high temperature for a short time have a high degree of whiteness compared to the untreated product.

Table 7

	Heating Conditions	pH Adjustment	Degree of Whiteness (L value) 1)
Comparative	120°C for 18 minutes	not adjusted (pH 6.95)	62.5
Comparative	100°C for 44 minutes	adjusted (pH 5.30)	70.3
This invention	120°C for 11 minutes	adjusted (pH 5.30)	75.1
This invention	135°C for 5.6 minutes	adjusted (pH 5.30)	78.4
Comparative	no retort treatment	not adjusted (pH 6.95)	84.4

Note: 1) The measurement was carried out using a Nippon Denshoku Color Machine (CM20) and a standard white board with an L value of 92.12.

Spores of Clostridium sporogenes, NCA-PA3679 were mixed into the material during the kneading process in an amount of 10^3 spores/g, and 50 packages each were thermally sterilized under the conditions shown in Table 7. The sterilized packed pasty products were stored at 37°C for 2 months in an isothermal room, but no putrefaction was observed except in the untreated product.

Practical Example 7

Mottled kidney beans, soaked in water overnight were boiled until they were soft, and the boiling liquid was discarded. Subsequently, 2 cups of cane sugar and 1/4 teaspoon of table salt per cup of the beans were added to the softened beans, were heated and after the sugar was melted the mixture was cooked for another 30 minutes with a low fire.

The cooked mottled kidney beans prepared as described had a water activity of 0.87 and a pH of 6.86. The beans, 170 g, were packed in a retort pouch (hi-RP-T), and sealed under vacuum of 30 cm Hg to give a package with 13 mm thickness. The packages, 50 of them, were stored without any thermal sterilization treatment at 37°C for 2 weeks in an isothermal room. As a result, all of the packages were expanded and the beans packed therein were putrefied. These 50 packages were each thermally sterilized under the conditions of 100°C for 25 minutes, 120°C for 7 minutes, or 135°C for 4 minutes and were stored at 37°C for 2 months. They did not show any putrefaction at all.

The quality evaluation test of the four kinds of packed mottled kidney beans was carried out using the one prepared with the thermal treatment of 100°C for 25 minutes used as a standard, and were graded by the same method as the one used in Practical Example 1. The results are shown in Table 8 below. From the results shown in Table 8, it is apparent that a product with an excellent quality may be obtained from the foods with a low water activity by carrying out the thermal treatment of this invention at a high temperature for a short period.

Table 8

	Heating Conditions	Average Evaluation Points
Comparative	no retort treatment	3.0
Comparative	100°C for 25 min.	0
This invention	120°C for 7 min.	2.1
This invention	135°C for 4 min.	2.7

lowering the pH of the food to the range of 4.6 to 5.5 by adding a pH adjusting agent,

adding a proper amount of sweetener to the extent that the sour taste of the food which has been induced by lowering the pH will not be present,

placing the thus modified food in the container and heremetically sealing the container, and then,

sterilizing the modified food by heating at 115-150°C for a shorter time than that required for completely sterilizing the unmodified food having a pH higher than 5.5.

3. A process of claim 1 or 2, wherein said shorter time is less than 20 minutes.

4. A process of claim 1 or 2, wherein said pH adjusting agent comprises malic acid, citric acid, fumaric acid and gulcono-deltalactone.

5. A process of claim 2, wherein said sweetener comprises sorbitol, fructose and cane sugar.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A process of making a sterilized food package characterized in the steps of:

providing a container formed of a packaging material capable of withstanding a sterilization treatment of 115-150°C,

supplying a food to be packaged having inherently a pH higher than 5.5,

lowering the pH of the food to the range of 4.6 to 5.5 by adding a pH adjusting agent, to such an extent that a sour taste will not be present with the food,

placing the thus modified food in the container and hermetically sealing the container, and then

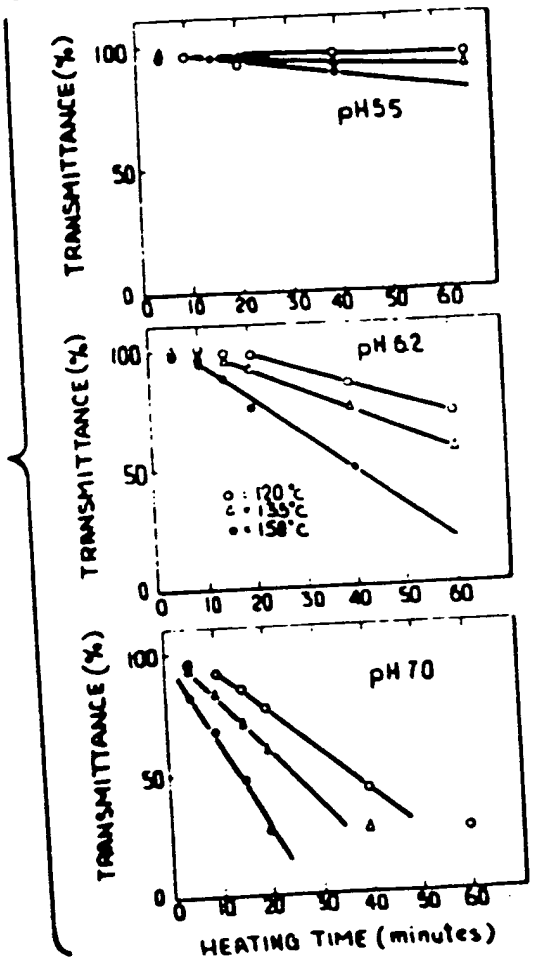
sterilizing the modified food by heating at 115-150°C for a shorter time than that required for completely sterilizing the unmodified food having a pH higher than 5.5.

2. A process of making a sterilized food package characterized in the steps of:

providing a container formed of a packaging material capable of withstanding a sterilization treatment of 115-150°C,

supplying a food to be packaged having inherently a pH higher than 5.5,

FIG.3


TRANSMITTANCE (%)
100
50
0
pH 5.5
pH 6.2
pH 7.0
o : 120°C
Δ : 135°C
• : 150°C
0 10 20 30 40 50 60
HEATING TIME (minutes)

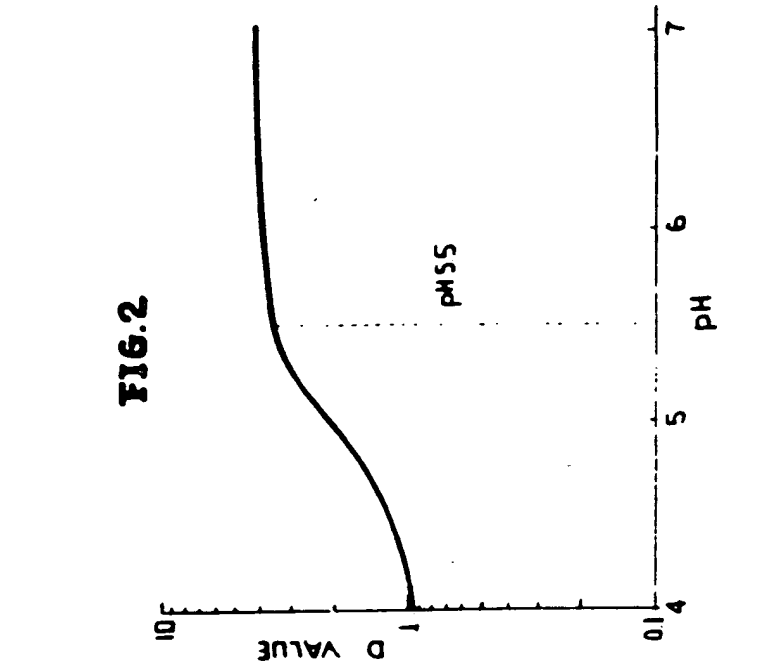

D VALUE
10
1
0.1
4
5
6
7
pH
pH 5.5

FIG.2

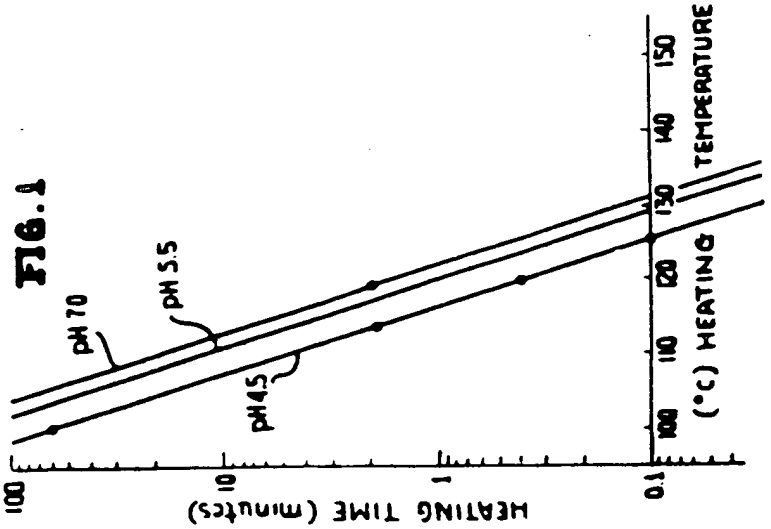

HEATING TIME (minutes)
100
10
1
0.1
pH 7.0
pH 5.5
pH 4.5
100
110
120
130
140
150
(°C) HEATING TEMPERATURE

FIG.1